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High-resolution monolithic detector design for clinical PET systems: Advanced optical simulation study

M. Stockhoff[1], R. Van Holen[1, 2], S. Vandenberghe[1]

[1] *UGent, Department of Electronics and Information Systems, Gent, Belgium*
[2] *Molecubes, Gent, Belgium*

Content

PET detector design aims at high detection efficiency for 511 keV gamma rays in combination with precise spatial and depth information on the detection position in the crystal. Fast processing of these signals is required due to high count rates. Clinical positron emission tomography detectors today consist of pixelated scintillation crystals. A promising alternative are monolithic (continuous) crystals which are already successfully implemented in preclinical systems and can outperform the pixelated detector blocks. For the use in clinical PET systems, we simulate a 50x50x16 mm^3 scintillation block coupled to an 8x8 SiPM array (6x6 mm^2) in GATE. An advanced photon reflection model based on measured crystal surface data is used. Calibration data is acquired and organized into 5 depth-dependent layers based on the signal standard deviation. Events are positioned with the mean nearest neighbor method. The average spatial resolution in terms of FWHM is 0.83 ± 0.20 mm while simulations without Compton scatter resulted in a resolution of 0.56 ± 0.13 mm. The positioning bias is found to be largest for interactions close to the SiPM array due to insufficient light spread. The depth estimation for Future studies will include calibration of the complete detector. The optimization of positioning accuracy in the bottom layers will be tested by a reduction of pixel size with multiplexed read-out and the use of a light guide to improve spatial resolution/ positioning bias for events close to the SiPM array.